Development of Biotechnology E-Module Based on Integrated Project Based Learning with STEM Approach

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Abstract. This study purpose to develop an electronic module (e-module) based on project-based learning integrated with STEM (Science, Technology, Engineering, Mathematics) approach. This study is a research and development research, by adopting steps according to the ADDIE model, namely Analyze, Design, Develop, Implement and Evaluation. The data collection method used is using questionnaires and interviews, while the data analysis technique uses descriptive qualitative and quantitative analysis. The e-module developed is considered highly valid by material expert validators and media expert with score 95,83 and 94,23 respectively. The e-module practicality test was conducted on 30 students with score 98,67 or very good category. Based on the results of this study, it can be concluded that the STEM integrated project-based biotechnology e-module is declared very feasible and practical to be used in learning Biotechnology courses.

Keywords: Biotechnology · E-module · Project Based Learning · STEM

1 Introduction

The new paradigm of the 21st Century science education explores a wide range of possibilities that can foster students' interest in science and creative convergent thinking [1]. Skills such as the ability to communicate, think creatively, collaborate, think critically, solve problems supported by the mastery of technology are competencies that must be mastered [2]. The 21st century is known as digital age, where all sectors, including education, should be digitalized, and in which technologies play a fundamental role in education. For this reason, educational development should be oriented towards the use of ICT (Information Communication and Technology) as the management system [3]. This technological very rapid development provides opportunities for the world of education to make it easier to obtain information in the form of text, images, videos, and animations. As an effort to adapt to the development of module technology to be made in the electronic form to make it more practical and efficient [4]. Electronic module (E-module) is one of the media that can be used in accordance with this trend.

The module can be a solution because it has five characteristics main that become its advantages, namely self-instructional, self-contained, stand-alone, adaptive, and user

M. Kristiawan et al. (Eds.): OCERI 2023, ASSEHR 775, pp. 181–188, 2024.
https://doi.org/10.2991/978-2-38476-108-1_17

friendly. Besides, e-modules are very practical because they are easily accessed by students wherever and whenever [4]. E-module is a presentation of teaching materials electronically and can be used independently, is designed completely and systematically in a particular learning unit and is presented in an electronic format, where each learning process is linked by a link that is able to realize learning. E-modules are more interactive and are equipped with other learning media such as video, audio, and animation to enrich students' learning experiences. E-module is also a learning resource that contains material, methods, limitations and systematic and interesting evaluation methods designed to electronically achieve competencies that correspond to difficulties. The e-module is designed in accordance with the curriculum and is made in the form of non-printed teaching materials with displays using electronic devices such as computers or androids. E-module is an independent learning media that contains only one learning material [5]. One of the courses that require modules as teaching materials for independent learning is project-based learning such as the Biotechnology course.

The Biotechnology course is a compulsory subject in the Science Education Study Program at the University of Bengkulu. So far, learning of the Biotechnology subject at the Science Education Study Program at the University of Bengkulu has been carried out on a project-based learning (PjBL) basis. The results of the learning evaluation for 50 students in 2020/2021 academic year showed that students consider Biotechnology to be an interesting, challenging and fun subject. This is due to the characteristics of Biotechnology always develops along with the development of technology, dan biotechnology has the ability to answer challenges that will be faced in the future regarding various products from various fields of science [6]. Students enthusiastically take part in this course and are able to work on group project assignments given independently. However, in doing project assignments, students need guides or teaching materials that can be used as a guide in independent study and project work. Teaching materials that are suitable for student independent learning are in the form of e-modules. In order to combine contextual with project assignments and to achieve 21st century skills, the developed e-module needs to be integrated with the PjBL model and the STEM (Science, Technology, Engineering, Mathematics) approach.

STEM education, as one of the most striking educational movements in recent years, is an interdisciplinary field of study linking science, technology, engineering, and mathematics [7]. STEM integration can train students' scientific attitudes and thinking levels because it requires students' direct involvement to take an active role in the learning process. In addition, STEM can increase students' interest and motivation in higher-order thinking skills such as problem solving and collaboration. This is a great way for educators to teach students about STEM concepts, principles, and methodologies in an integrated way when applied in the real world to develop products, processes, and systems [8].

Learning using the PjBL model involves students in real or simulated experiences and makes students more independent so they can improve their creative thinking skills [9]. Project-based learning is more appropriate in interdisciplinary learning because it naturally involves many different academic skills, such as reading, writing, and mathematics and is appropriate in building conceptual understanding through the assimilation of different subjects [10].

STEM-integrated PjBL can increase student interest in learning, learning becomes more meaningful, assisting students in solving real-life problems, and supporting future careers. In addition, STEM in PjBL provides challenges and motivates students because it trains students to think critically, analyze and improve higher-order thinking skills. Through STEM learning, students have scientific and technological literacy that can be seen from reading, writing, observing, and doing science so that they can be used as provisions for living in society and solving problems faced in everyday life related to the STEM field of science [10].

2 Methods

This research is an R & D research using the ADDIE model [11], which consists of five phases: Analyze, Design, Develop, Implement, and Evaluate. However, in this study was determined by Analyze, Design and Develop stage.

1. Analyze. At this stage a needs was conducted in order to gain a product which are appropriate and meet the target needs. The analysis was carried out by observation, interviews and questionnaires with students and lecturers on the Biotechnology course. This activity aims to find out the problems related to the learning process of Biotechnology in the Science Education Study Program.
2. Design. At this stage the researcher designed a project-based e-module by integrating STEM based on the previous need analysis. Activities at this stage were preparing material content in the e-module, determining the appearance or layout of the e-module, collecting references related to Biotechnology material
3. Develop. At this stage the researcher conducted the planning results at the design stage. The e-module design was then developed through the following steps: making e-module products, expert validation, and student practically response tests.

The subjects in this study were 30 students of Science Education Study Program, University of Bengkulu, who enrolled Biotechnology courses. Data collection techniques was using a questionnaire. The questionnaire was used to gain the validity and practicality of the e-module according to valuation from media expert and material expert, as well as students readability response tests. The instruments for collection of data were questionnaire consists of questionnaire validation of the media experts, a questionnaire validation material experts, questionnaires e-module practically of students.

The data is then analyzed to determine the validity and practicality of e-module. When the calculation of the percentage of validity obtained, then a decision is made regarding the validity of the module which refers to Table 1.

For the score of student assessment results on teaching materials from the readability test, the assessment criteria refer to Table 2.

Table 1. Criteria for Validity of Data and Decision Making on Revision of Module

Validity scale (%)	Criteria	Decision
86–100	Highly valid	Feasible and no revision
71–85	Valid	Feasible with minor revision
56–70	Sufficiently valid	Quite feasible with mayor revision
41–55	Less valid	Less feasible with mayor revision
25–20	Invalid	Not feasible and mayor revision

(Akbar, 2013)

Table 2. Student Response Criteria

Score (%)	Criteria
76–100	Very good
51–75	Good
26–50	Sufficiently
≤ 25	Not good

3 Results and Discussion

1) **Description of Developed E-Module Product**

The e-module was developed using the Microsoft Office Word application to compile material and then converted into a Professional Flip PDF file. The Canva application was used to create cover page, while to edit learning videos was by using the Kinemaster application. The e-module product was developed in 2 formats, namely in offline format (.exe) and online format (.html), therefore e-module is enable both offline and online. Developed E-module appearance is shown in Fig. 1.

The e-module is designed with the following structure:

a. Front cover

The front cover consists of the title of, author name, logo of institutions. The cover page of the module is designed with a harmonious, informative and attractive appearance of colors, pictures and layouts to attract students' interest.

b. Front Pages

The preliminary section consists of table of contents, list of tables, list of pictures, list of attachments, and introduction (consists of general explanation, instructions guide, learning outcomes of course, and objectives).

c. Main Pages (Content)

The content section consists of explanation of Biotechnology dan and learning activity integrated with STEM (Science, Technology, Engineering and Mathematic approach.

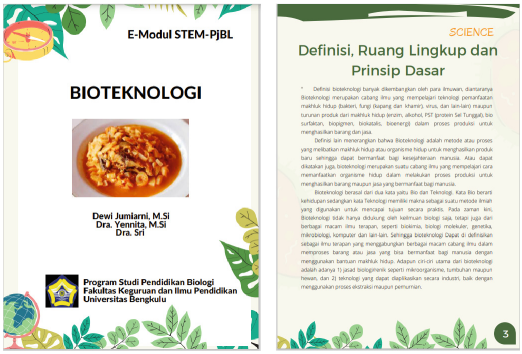

Fig. 1. E-module appearance

1. Science
Science aspect consist of theory and concept of biotechnology, modern and conventional biotechnology, principle of fermentation, examples of biotechnology.
2. Technology
Technology aspect consist of tools or devise used in learning process to enhance students understanding, namely video link, animated, journal links, news, and additional references.
3. Engineering
Engineering aspect consist of student learning activities in practicing the manufacture of conventional biotechnology products, such as making yogurt, tempeh, tape, and others. Students with their groups are ordered to determine a sample of biotechnology products to be practiced, design tools and ingredients, and arrange schedule. This is in accordance with the stages of project-based learning syntax.
4. Math
Math aspect consist of calculations of ingredients for making biotechnology products, measurement of temperature, pH, water content of products.

d. Back Pages
The back pages section consists of conclusion, evaluation test, and author's biography.

The e-module was developed by integrated STEM-based learning, which is consist of four aspects in one learning experience namely Science, Technology, Engineering and Mathematics. It needs to be applied through a project-based learning model, due to STEM implies an output in the form of design work in each lesson.The activities of project-based learning workshop for tutors consisting of: (1) make inquiries to be made into a project, (2) choose the main questions or specify the project, (3) reading and looking for material that is relevant to the issues, (4) design problem, (5) designing/the right method in solving problems, (6) writing projects proposals, (7) implementation and create documents task, (8) data analysis and make conclusions, (9) final report, (10) presented the final project [12].

2) **The Result Validity and Practicality Test of E-Module**

To assess the feasibility of the e-module designed, a feasibility test was carried out by means questionnaire assessment by validators of material expert and media expert. The e-module eligibility validation from material experts gain a score 94,23 or in higly valid category according to presentation, content, language, and STEM aspects. The e-module eligibility validation from media expert gain a score of 95,83 or with highly valid criteria according to technical, program and language aspects. The expert gave some suggestions, namely: 1) the e-module should highlight the manufacture of conventional biotechnology products based on local wisdom, such as making *lemea, tempuyak* and *tempeh*, 2) it should add a theoretical basis for the process of forming these products from the biochemical aspect so that students can understand more comprehensively, 3) in the mathematics component, data should be added in the form of graphs to train students' numeracy literacy.

The addition of activities in the form of projects in learning process will increase students' mastery concept of biotechnology topic [13]. Furthermore, a teaching material content with the value of local wisdom can educate students to be able to overcome the problems that exist around the students. Enhancing local wisdom in learning is expected to provide a new finding or innovation in producing teaching materials based on local wisdom, so preservation of local cultural values that characterize Indonesia nation can be maintained through the using of teaching materials in schools [14].

The use of the STEM approach can provide opportunities for students to understand the importance of integrating various disciplines and their applications. The STEM approach has comprehensive characteristics, thus providing opportunities for students to practice their thinking skills. STEM can develop problem-solving skills, attract students to be more interested in learning, thus developing higher-order thinking skills. This is due to PjBL-STEM provides experience for students to connect the knowledge that has been obtained with real life, thereby creating an interesting learning experience for students because students are required to think critically in solving problems. Furthermore, the students are also required to be able to collaborate so that students have the opportunity to provide ideas, improve products, as well as apply design skills (innovation). In line with [15], PjBL model with the STEM approach has the ability to invite students to carry out meaningful learning in understanding a concept and exploring through a project.

The e-module practicality test shows a score of 98,67 or very good criteria. The practicality of this e-module is due to its electronic form thus it can be read anywhere and anytime. In addition, this e-module is made using professional flipbook. According to Fajaryati & Pranoto, (2016), flipbook is a form of simple animations generated by opening the pages quickly. However, along with the development of information technology, this flipbook idea was adopted and used in the manufacture of digital books which enable them to be opened and inverted like a regular book. Flipbook is similar to an e-book. However, when e-book is a digital book that has monotonous look of texts and images, flipbook is equipped with animations, videos and quizzes that make it more attractive and interactive.

4 Conclusion

The e-module eligibility validation from both material expert and media expert are gain highly valid, as well as the e-module practicality test shows a score of 98,67 or very good criteria. It can be concluded that the STEM integrated project-based biotechnology e-module is declared feasible to be used in learning Biotechnology courses.

Acknowledgments. Authors thank to Fakultas Keguruan dan Ilmu Pendidikan (FKIP) Universitas Bengkulu for funding this valuable project by research grant contract number 3165/UN30.7/PP/2022.

References

1. G. A. Wandari, A. Fany, C. Wijaya, and R. R. Agustin, "The Effect of STEAM-based Learning on Students ' Concept Mastery and Creativity in Learning Light and Optics," vol. 2, no. December, 2018, doi: https://doi.org/10.17509/jsl.v2i1.12878.
2. H. W. Sofia, A. P. Utomo, S. Hariyadi, B. Wahono, and E. Narulita, "The validity and effectivity of learning using STEAM module with biotechnology game," *JPBI (Jurnal Pendidik. Biol. Indones.*, vol. 6, no. 1, pp. 91–100, 2020, doi: https://doi.org/10.22219/jpbi.v6i1.10979.
3. L. Sumardi, A. Rohman, and D. Wahyudiati, "Does the teaching and learning process in primary schools correspond to the characteristics of the 21st century learning?," *Int. J. Instr.*, vol. 13, no. 3, pp. 357–370, 2020, doi: https://doi.org/10.29333/iji.2020.13325a.
4. R. D. Kurniati, D. Andra, and I. Wayan Distrik, "E-module development based on PBL integrated STEM assisted by social media to improve critical thinking skill: A preliminary study," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1796, no. 1, 2021, doi: https://doi.org/10.1088/1742-6596/1796/1/012077.
5. I. Rahayu and S. Sukardi, "The Development Of E-Modules Project Based Learning for Students of Computer and Basic Networks at Vocational School," *J. Educ. Technol.*, vol. 4, no. 4, p. 398, 2021, doi: https://doi.org/10.23887/jet.v4i4.29230.
6. P. Qalbina and Y. Ahda, "Characteristics of biotechnology learning materials generally used by biology education students in Padang City," *J. Phys. Conf. Ser.*, vol. 1185, no. 1, 2019, doi: https://doi.org/10.1088/1742-6596/1185/1/012154.
7. S. Ceylan, S. A. Zeynep, and A. K. Seyit, "STEM S kills in the 21 st C entury E ducation," vol. 7, no. December 2018, pp. 1–16, 2016.
8. H. Karnia, M. Erna, and H. Herdini, "Development of STEM (Science, Technology, Engineering and Mathematics) Integrated E-Modules with the Assistance of Pageflip Professional 3D Software on the Subject of Acid-Base," *Edukimia*, vol. 4, no. 1, pp. 033–043, 2022, doi: https://doi.org/10.24036/ekj.v4.i1.a329.
9. R. N. A. A. Fajrina, S. K. Handayanto, and A. Hidayat, "The Role of the Project Based Learning Model in the Creative Thinking Ability of Class XI IPA through Static Fluid Material," *J. Pendidik. Teor. Penelitian, dan Pengemb.*, vol. 3, no. 3, pp. 291–295, 2018, [Online]. Available: http://journal.um.ac.id/index.php/jptpp/article/view/10625/5202.
10. J. Afriana, A. Permanasari, and A. Fitriani, "Implementation of STEM-integrated project-based learning to increase students' scientific literacy in terms of gender," *J. Inov. Pendidik. IPA*, vol. 2, no. 2, p. 202, 2016, doi: https://doi.org/10.21831/jipi.v2i2.8561.
11. R. . Branch, *Instructional Design*. 2021.

12. E. Indrawan and S. Jalinus, Nizwardi, "Review Project Based Learning," *Int. J. Sci. Res.*, vol. 8, no. 4, pp. 1014–1018, 2018, [Online]. Available: www.ijsr.net.
13. D. Jumiarni, R. Zulni, E. Putri, R. N. Sasongko, and E. W. Winarni, "Development of Android Based E-Module on Biotechnology Topic," pp. 1135–1148, 2022, doi: https://doi.org/10.30868/ei.v11i03.2653.
14. A. Y. Zukmadini, D. Jumiarni, and K. Kasrina, "Developing antimicrobial medicinal plants pocketbook based on local wisdom of Muko-Muko and Serawai ethnics," *JPBI (Jurnal Pendidik. Biol. Indones.*, vol. 4, no. 2, pp. 95–104, 2018, doi: https://doi.org/10.22219/jpbi.v4i2.5436.
15. A. Fitriyani, T. Toto, and E. Erlin, "Implementation of the PJBL-STEM Model to Improve Higher Order Thinking Skills," *Bioed J. Pendidik. Biol.*, vol. 8, no. 2, p. 1, 2020, doi: https://doi.org/10.25157/jpb.v8i2.4375.
16. N. Fajaryati and P. W. Pranoto, "E-Module Development for the Subject of Measuring Instruments and Measurement," *J. Pendidik. Teknol. dan Kejuru.*, vol. 23, no. 2, pp. 191–199, 2016.